PB83-246108

Waterborne Outbreaks in the United States, 1971-81

(U.S.) Health Effects Research Lab.
Cincinnati, OH

Aug 83

U.S. Department of Commerce
National Technical Information Service
NTIS

?B83-246108

EPA-600/D-83-111
August 1983

WATERBORNE OUTBREAKS IN THE UNITED STATES

1971-1981

by

Gunther F. Craun
Steven C. Waltrip
Arthur F. Hammonds

U.S. Environmental Protection Agency

Cincinnati, Ohio

EPA Project Officer
Gunther F. Craun

HEALTH EFFECTS RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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NATIONAL TECHNICAL
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SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
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1. REPORT NO. EPA-600/D-83-111	2.
3. RECIPIENT'S ACCESSION NO. PB83-246108	
4. TITLE AND SUBTITLE: Waterborne Outbreaks in the United States, 1971-81	5. REPORT DATE: 1983
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): G. Craun, S. Waltrip, A. Hammonds	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US EPA, Health Effects Research Laboratory, Toxicology and Microbiology Division, Chemical and Statistical Support Branch, 26 W. St. Clair St., Cincinnati, Ohio 45268	10. PROGRAM ELEMENT NO. ABMCIA
	11. CONTRACT/GRANT NO. In-house
12. SPONSORING AGENCY NAME AND ADDRESS: Health Effects Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA-600/11

15. SUPPLEMENTARY NOTES: To be included as part of the proceedings AMA/EPA Symposium on Drinking Water and Health, Wash., DC, 4/7-10/83 & possible Book Chapter Waterborne Diseases in the U.S.

16. ABSTRACT (CRC Publishing Company)

Since 1971 the Environmental Protection Agency and the Center for Disease Control have cooperated in the investigation and reporting of waterborne outbreaks in the United States. Three hundred and twenty waterborne outbreaks affecting 77,989 individuals were reported during 1971-80 by 43 states and Puerto Rico. Three deaths were associated with these outbreaks. Thirty-five outbreaks and 4,450 cases of waterborne disease were reported in 1981. Most outbreaks occurred in noncommunity water systems but most of the disease resulted from outbreaks in community water systems. There is a seasonal distribution of outbreaks in noncommunity and individual water systems with most outbreaks occurring in the summer months and affecting primarily travelers, visitors to recreational areas, campers, and restaurant patrons. The major causes of waterborne outbreaks in community systems were inadequate or interrupted treatment and contamination of the distribution system; for noncommunity systems contamination of groundwater used without treatment and treatment deficiencies, primarily interrupted or inadequate disinfection, were responsible for almost all outbreaks. An etiologic agent was determined in about 45% of the outbreaks with Giardia lamblia the most commonly identified pathogen. Chemical agents were responsible for about 12% of the outbreaks.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT: Release to Public	19. SECURITY CLASS (This Report) unclassified	21. NO. OF PAGES 46
	20. SECURITY CLASS (This page) unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

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Since 1971 the Health Effects Research Laboratory, Environmental Protection Agency (EPA), Cincinnati, Ohio, and the Centers for Disease Control (CDC), Atlanta, Georgia, have cooperated in the investigation and reporting of waterborne disease outbreaks in the United States. Local and state health departments investigate waterborne disease outbreaks and at times request assistance from CDC and EPA. As part of the reporting system, state epidemiologists and engineers in state water supply surveillance agencies provide data on waterborne outbreaks to EPA and CDC annually. This report summarizes data reported to EPA and CDC on waterborne outbreaks during 1971-1980. Supplemental data for 1981 are also provided.

Outbreaks associated with water used or intended for drinking or domestic purposes and outbreaks associated with the use of contaminated springs and creeks by backpackers and campers are included; waterborne outbreaks occurring in cruise ships operating from U.S. ports are excluded. To be considered an outbreak, at least two cases of disease must be reported. This is necessary so that a common source can be noted and investigated. Except in unique circumstances, such as a case of chemical poisoning in which the chemical is identified, a single case of illness cannot be recognized as having been caused by drinking water. Single cases of infantile methemoglobinemia associated with high nitrate concentrations in water have been included in this reporting system since 1979.

The waterborne outbreaks reported here are those in which drinking water has been epidemiologically implicated as the vehicle of transmission of the illness. In most of the outbreaks the water was also found to be bacteriologically or chemically contaminated, but in only a few outbreaks was the etiologic agent isolated from drinking water.

For analysis the water systems are classified as community, noncommunity, and individual according to definitions contained in the Safe Drinking Water Act (P.L. 93-523). Community water systems are public or investor-owned water supplies serving large or small communities, subdivisions, and trailer parks having at least 25 year-round residents or 15 service connections used by year-round residents. Noncommunity water systems must regularly serve an average of at least 25 individuals for 60 or more days out of the year. These systems primarily serve transients and include institutions, industries, camps, parks, hotels, and service stations which have their own water supply available for use by employees and the general public. Individual water systems are used by single residents in areas without community systems or by persons traveling outside of populated areas (e.g., backpackers, campers).

The outbreaks reported during 1971-80 were reviewed to ensure the accuracy of data entered into the IBM-370/168 computer system maintained by EPA. This resulted in minor changes to data previously reported in CDC's "Annual Summary of Waterborne Outbreaks." Changes were made primarily in dates and water system classifications. Because of reporting delays some outbreaks had previously been identified by date of report rather than date of occurrence. Changes in water system classifications were required so that definitions would correspond to those in the Safe Drinking Water Act. Printing errors noted in previous summaries were also corrected.

Outbreaks (1971-80)

Three hundred and twenty waterborne outbreaks (Fig. 1) affecting 77,989 individuals (Fig. 2) were reported during 1971-1980 by 43 states and Puerto Rico. Three deaths were associated with these outbreaks. No outbreaks were reported by Delaware, Kansas, and Nevada during this period.

There has been a pronounced increase in the number of waterborne outbreaks reported since 1971; an average of 39 outbreaks per year were reported during the period 1976-1980 compared to 25 per year reported during the period 1971-1975. This increased number of reported outbreaks is felt to be primarily the result of more active surveillance, but this cannot be quantified at present. Although reporting has generally improved since 1971, more waterborne outbreaks occur than are reported through this surveillance system. Reporting depends upon many factors, including the type of water system, severity of disease, number of individuals affected, and interest and capabilities for recognition and investigation at the State and local level. It is difficult to ascertain the number of waterborne outbreaks that go undetected or unreported. One estimate, based on data collected from 1946-1970, was that about one-half of the waterborne outbreaks in community water systems and about onethird of those in noncommunity systems are detected, investigated, and reported (1). During a two-year period of improved waterborne disease surveillance in Colorado in 1980-1982, 11 waterborne outbreaks were documented compared to six waterborne outbreaks during the previous three-year period. A study (2) of the occurrence of foodborne outbreaks in Washington State indicated that prior to initiation of improved surveillance and investigation only one foodborne outbreak in ten had been recognized and reported. Although this number referred to foodborne outbreaks it may be applicable to waterborne outbreaks, especially those that occur in noncommunity water systems, because of similarities in recognition and investigation of these kinds of outbreaks.

Outbreaks in community water systems, which number about 59,000 and serve about 180 million people, are probably the most likely to be reported. Outbreaks in noncommunity systems, which number about 240,000 and serve about 20 million people, primarily transients, are the next most likely to be reported.

The least likely to be reported are outbreaks in individual water systems, which serve about 30 million people (3). One hundred and twenty-three waterborne outbreaks were reported in community water systems, 160 outbreaks in noncommunity water systems, and 37 outbreaks in individual water systems during 1971-80 (Fig. 3).

Although most outbreaks occurred in noncommunity systems (50%), most illness (76%) resulted from outbreaks in community systems (Fig. 4). During 1971-80, outbreaks in community systems affected an average of 482 persons (Fig. 5) compared to 115 persons per outbreak in noncommunity systems (Fig. 6) and 10 persons per outbreak in individual systems.

There appears to be a seasonal distribution of outbreaks in noncommunity water systems with the largest number of outbreaks occurring during the summer months; these outbreaks affect primarily travelers, campers, restaurant patrons, and visitors to recreational areas (Fig. 7). It is difficult to ascertain if this seasonal distribution is a result of increased contamination of noncommunity water supplies during the summer or due to an increased number of susceptible individuals using water supplies which are always contaminated. The small seasonal increase seen for outbreaks affecting usual residents in noncommunity systems would suggest that there is increased contamination during the summer for some of these water systems. Outbreaks occurring among residents using individual water systems, which are primarily groundwater systems, also show a slightly increased occurrence during the summer months (Fig 8). There was little seasonal variation for outbreaks in community water systems; however, more outbreaks occurred in the month of July than any other month (Fig. 9).

Cause of Outbreaks (1971-80)

The major cause of waterborne outbreaks (39%) and waterborne disease (65%) for all types of water systems during this ten-year period was inadequate or interrupted treatment of water sources (Fig. 10). Use of contaminated, untreated groundwater was responsible for 33% of the outbreaks and 11% of the waterborne disease. Contamination of the distribution system was responsible for 16% of the outbreaks and 19% of the waterborne disease.

Specific sources of contamination were examined within each of these water supply deficiencies (Tables 1 to 4). Ninety-two outbreaks occurred in well water systems used without treatment (Table 1). Overflow or seepage of sewage, primarily from septic tanks or cesspools, was responsible for 38% of the outbreaks and 58% of the illness caused by use of contaminated, untreated well water. This included outbreaks where contaminants travelled through limestone or fissured rock. Eleven percent of the outbreaks and 2% of the disease in untreated well water systems were caused by chemical contamination. There were insufficient data to establish a source of contamination for 35% of these outbreaks, emphasizing the need for better engineering investigations if contamination problems for untreated groundwater sources are to be understood. There are a few communities, individuals, and establishments that still use surface water and spring water without treatment. Most of the outbreaks caused by use of contaminated, untreated surface water and spring water also had insufficient data to establish the source of contamination.

Most of the outbreaks (87%) and most of the illness (85%) caused by treatment deficiencies occurred as the result of inadequate or interrupted disinfection (Table 2). In some areas of the country, surface water sources are treated only by disinfection. There were 39 outbreaks and 18,966 cases of illness caused by inadequate or interrupted chlorination of surface water;

one outbreak of 900 cases of illness resulted from interruption of UV light disinfection.

Well water systems usually depend on a relatively good quality water, and disinfection is oftentimes provided primarily to protect against possible contamination of the distribution system. In this situation unexpected contamination of the source could completely overwhelm the disinfection provided. For groundwater systems using a source known to be frequently or intermittently contaminated with bacteria, continuous disinfection is necessary to ensure potability until the sources of contamination are located and removed, improvements made in source protection, or alternative water sources developed. Outbreaks are then caused by inadequate disinfection of the contaminated source water or interrupted disinfection due to equipment malfunction or an insufficient supply of the disinfectant. Inadequate or interrupted disinfection of well water was responsible for 54% of the outbreaks and 48% of the illnesses caused by treatment deficiencies in water systems where disinfection was the only treatment. Most of these outbreaks in well water systems were associated with the use of chlorine for disinfection, but four outbreaks were caused by inadequate or interrupted disinfection by iodine. These occurred in small noncommunity systems serving primarily a transient population.

There appears to be a seasonal distribution for outbreaks occurring in surface water systems (Fig. 11) and in groundwater systems (Fig. 12). Outbreaks caused by use of contaminated, untreated surface water were more likely to occur during July-September while outbreaks caused by inadequate or interrupted disinfection of surface water occurred primarily in June and July. Outbreaks in groundwater systems, whether caused by use of contaminated, untreated groundwater or by adequate or interrupted disinfection,

occurred most often during the period of June-August. It is felt that this seasonal distribution primarily reflects increased contamination of these sources during the summer months, although increased water demands, especially by the travelling public, and poor operation and treatment are important contributing factors.

The major causes of outbreaks in community systems (Fig. 13) were treatment deficiencies (49%) and contamination of the distribution system (32%). Treatment deficiencies, such as inadequate filtration and interruption of disinfection, were responsible for most of the illness in community systems. Ineffective pretreatment and/or filtration was documented in six outbreaks causing 7,055 cases of waterborne illness. Almost all of the waterborne illness caused by distribution system deficiencies was due to cross-connections, backsiphonage, contamination of water mains, and contamination of distribution storage (Table 3), and most of these outbreaks occurred in community systems. An estimated 5,000 cases of acute gastroenteritis in Sewickley, Pennsylvania, were caused by contamination of an uncovered storage reservoir for treated water and 1,400 cases of a similar illness in Sellersburg, Indiana, were traced to sewage contamination of a water main during construction.

Contamination of groundwater used without treatment and treatment deficiencies, primarily interrupted and inadequate disinfection, were responsible for almost all outbreaks (83%) and illness (80%) in noncommunity systems (Fig. 14). The major cause of outbreaks (84%) and illness (85%) in individual water systems was use of contaminated, untreated surface water or groundwater (Fig. 15).

Etiology (1971-80)

An etiologic agent was determined in 45% of the outbreaks (Fig. 16). The remaining outbreaks were categorized as acute gastrointestinal illness charac-

terized by symptoms including abdominal cramps, nausea, vomiting, and diarrhea occurring 12 to 48 hours after consumption of water. In many of the outbreaks, the search for an etiologic agent included only stool cultures for Salmonella and Shigella; in others the investigation and collection of clinical specimens were delayed. Thus, some of the outbreaks of undetermined etiology may have been caused by (1) common bacterial agents which were not identified because no laboratory analysis was conducted or (2) less common bacterial agents, viruses, or parasites because the appropriate testing was not done.

Outbreaks of acute diarrheal disease have been caused by toxigenic strains of E. coli, and the etiology of a large waterborne outbreak that occurred in 1975 at Crater Lake National Park was identified as enterotoxigenic E. coli serotype O6:H16. However, pathogenic testing of E. coli isolates is not routinely done in waterborne outbreaks, and it is difficult to estimate how many of the waterborne outbreaks of undetermined etiology may have been caused by this agent.

In several of the largest outbreaks during this ten-year period, extensive laboratory analysis of human specimens and water samples, including appropriate tests for newly recognized bacterial and viral pathogens, parasites, and chemicals did not demonstrate an etiology, suggesting that additional unrecognized agents may be responsible for some outbreaks of acute gastrointestinal illness.

Twelve percent of the outbreaks were chemical poisonings involving arsenic, chlordane, chromate, copper, cutting oil, developer fluid (hydroquinone, paramethylamino phenol), ethyl acrylate, fluoride, fuel oil, fluradan, lead, leaded gasoline, a mixture of lubricating oil and kerosene, nitrate, phenol, polychlorinated biphenyl, selenium, and an unidentified herbicide (Fig. 16; see also Table 5).

Six outbreaks of acute copper poisoning with copper levels of 4, 12.5, 38.5, and 80 mg/L illustrate problems associated with the leaching of metals from water distribution systems: (1) naturally aggressive water with a low pH in contact with copper plumbing caused high levels of copper to be dissolved into the drinking water; (2) pH adjustment of naturally aggressive water was interrupted allowing copper to be leached from copper plumbing; (3) a defective check valve allowed carbon dioxide from a drink dispensing machine to flow into the drinking water system causing the water to become aggressive to copper plumbing; and (4) high levels of copper from a drinking fountain were felt to be caused by low water utilization and no flushing of the feed line or electrolysis because of improper electrical grounds.

Seven outbreaks of acute fluoride poisoning were caused by improperly designed or malfunctioning fluoridation equipment and operational problems in the addition of fluoride (Table 6). These outbreaks illustrate the need for improved design of fluoridation equipment and increased surveillance and operator training in fluoridation practices. Four outbreaks occurred at elementary schools having their own water system. In the largest outbreak, 201 students and 12 adults became ill minutes after consuming orange juice made from the school's water supply, which had a fluoride concentration of 270 mg/L. The fluoride feeder pump at the wellsite had malfunctioned, causing fluoride to be fed continuously even while the water pump was not operating.

The most commonly identified pathogen was Giardia lamblia, a flagellated protozoan responsible for giardiasis. Thirty-nine waterborne outbreaks of giardiasis were reported during 1971-1980. Twenty-seven outbreaks occurred as the result of drinking untreated surface water or surface water whose only treatment was simple chlorination (Table 7). Ineffective filtration of surface water was responsible for five outbreaks and 6,981 cases of illness.

There were 22 outbreaks of waterborne giardiasis in community systems and 12 outbreaks in noncommunity systems (Tables 8-10). The noncommunity systems affected were primarily small systems in recreational areas. Outbreaks of waterborne giardiasis generally involved two distinct groups of people, usual residents or visitors. Although the data are limited there appears to be a seasonal trend of outbreaks in visitors during the summer months. Outbreaks involving usual residents seem to occur primarily in the fall through early spring.

In recent years, Norwalk-like agent(s) and rotavirus have been established as a cause of nonbacterial diarrheal outbreaks and have been transmitted by the waterborne route. These and other viruses that have yet to be fully characterized may be important as a cause of some waterborne outbreaks of gastroenteritis of undetermined etiology. Ten waterborne outbreaks of viral gastroenteritis have been identified. Most outbreaks have occurred in noncommunity water systems and have affected primarily visitors. Six outbreaks occurred in well water systems where the water received no treatment or the disinfection provided was either inadequate or interrupted. Two outbreaks were caused by cross-connections or backsiphonage. Coliform contamination of the water supply was evident in all outbreaks.

Sixteen waterborne outbreaks of hepatitis A occurred during 1971-1980, and since 1946 hepatitis A has been epidemiologically implicated in 69 waterborne outbreaks (Table 11). Half (11) of the outbreaks in community systems occurred as the result of contamination of the distribution system, primarily through cross-connections and backsiphonage. For noncommunity and individual systems, the use of contaminated, untreated groundwater was the important factor responsible for waterborne outbreaks of hepatitis A. There is no evidence that either hepatitis A virus or parvovirus-like agents have been

transmitted through correctly operated conventional water-treatment systems except where distribution defects have been found as the source of the contamination.

Waterborne diseases resulting from outbreaks caused by the use of contaminated, untreated water, inadequate or interrupted disinfection, and cross-contaminations were identified to determine which diseases might be associated with these deficiencies (Tables 12 and 13). Giardiasis and gastroenteritis of undetermined etiology were the two diseases most often transmitted by untreated and disinfected only surface water sources. The disease most often transmitted via well water systems was gastroenteritis of undetermined etiology. Acute chemical poisonings were identified in 11% of the outbreaks that occurred in untreated well water systems. Shigella was the most commonly identified pathogen transmitted via well water systems and was identified in 11% of the outbreaks in untreated well water systems and 11% of the outbreaks in well water systems with inadequate or interrupted disinfection. Outbreaks caused by cross-connections and backsiphonage were of various etiologies (Table 13). Gastroenteritis of undetermined etiology and acute chemical poisonings were reported most often, but giardiasis, viral gastroenteritis, hepatitis A, shigellosis, and salmonellosis were also transmitted in this manner.

Outbreaks (1981)

Thirty-two outbreaks and 4,430 cases of illness were associated with potable water systems in 1981. An additional three outbreaks and twenty cases of illness were caused by consumption of contaminated water not meant for drinking. An etiologic agent was determined in 57% of these outbreaks (Fig. 17 and 18). The most commonly identified pathogen was Giardia lamblia. There were five outbreaks caused by chemicals (lead, copper, fluoride, and nitrate);

three of these were associated with lead or copper being leached from plumbing materials by corrosive water. The largest waterborne cholera outbreak in the United States during this century occured in Texas; V. cholera 01 was responsible for 17 cases of severe diarrhea caused by sewage contamination of an oil rig's potable water system via a cross-connection. The waterborne transmission of rotavirus has been suggested recently by reports from other countries, and this pathogen was identified in a waterborne outbreak for the first time in the United States. One waterborne rotavirus outbreak resulting in 1,761 cases of illness occurred in a Colorado resort community in March 1981.

Acknowledgements

This report would not have been possible without the dedicated epidemiologists, engineers, sanitarians, nurses, microbiologists, and chemists in local and state public health agencies who uncover and investigate outbreaks. Knowledge obtained from their investigations not only helps correct deficiencies in water systems during an outbreak but also provides the documentation which can assist public health officials in the development of surveillance programs to prevent the occurrence of similar outbreaks. Special appreciation is expressed to our colleagues at CDC and EPA, especially Ed Lippy, who has supervised EPA's activity in this area over the past several years, and to Lon Winchester for his assistance in typing and editing this manuscript.

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TABLE 1

WATERBORNE OUTBREAKS IN UNTREATED WATER SYSTEMS

1971-80

CAUSE OF OUTBREAK	OUTBREAKS	ILLNESSES
CONTAMINATED SURFACE WATER		
1. USED FOR SUPPLEMENTAL WATER SOURCE	3	539
2. CONTAMINATION ON WATERSHEAD	2	41
3. OVERFLOW OF SEWAGE NEAR WATER INTAKE	1	25
4. HEAVY RAINS	1	79
5. INSUFFICIENT DATA	18	249
	25	933
CONTAMINATED GROUNDWATER (SPRINGS)		
1. SURFACE RUNOFF, HEAVY RAINS	3	126
2. INSUFFICIENT DATA	7	914
	10	1,040
CONTAMINATED GROUNDWATER (WELLS)		
1. OVERFLOW OR SEEPAGE OF SEWAGE	30	2,953
2. CHEMICAL CONTAMINATION	10	140
3. SURFACE RUNOFF, HEAVY RAINS	6	339
4. CREVICED LIMESTONE, FISSURED ROCK	5	1,221
5. CONTAMINATED BY STREAM OR RIVER	4	74
6. IMPROPER CONSTRUCTION, FAULTY WELL CASING	3	101
7. FLOODING	2	540
8. INSUFFICIENT DATA	32	1,847
	92	7,216

TABLE 2

WATERBORNE OUTBREAKS CAUSED BY TREATMENT DEFICIENCIES

1971-80

CAUSE OF OUTBREAK	OUTBREAKS	ILLNESSES
DISINFECTION ONLY TREATMENT		
1. OVERFLOW OR SEEPAGE OF SEWAGE SUFFICIENT TO OVERWHELM NORMAL DISINFECTION		
A. SURFACE WATER SYSTEMS	2	2,740
B. WELL WATER SYSTEMS	3	137
C. SPRING WATER SYSTEMS	3	1,249
	8	4,126
2. INADEQUATE DISINFECTION		
A. SURFACE WATER SYSTEMS	23	15,070
B. WELL WATER SYSTEMS	16	12,319
	39	27,389
3. INTERRUPTION OF DISINFECTION		
A. SURFACE WATER SYSTEMS	15	2,056
B. WELL WATER SYSTEMS	38	8,127
C. SPRING WATER SYSTEMS	5	1,123
	58	11,306
DISINFECTION WITH OTHER TREATMENT		
1. INADEQUATE DISINFECTION	1	41
2. INTERRUPTION OF DISINFECTION	1	26
3. INADEQUATE CONTROL OF FILTRATION/PRETREATMENT	6	7,055
4. INADEQUATE CONTROL OF CHEMICAL FEED	9	700
	17	7,822

TABLE 3

WATERBORNE OUTBREAKS CAUSED BY DISTRIBUTION DEFICIENCIES

1971-80

CAUSE OF OUTBREAK	OUTBREAKS	ILLNESSES
DISTRIBUTION SYSTEM		
1. CROSS-CONNECTION	19	5,656
2. BACKSIPHONAGE	13	1,428
3. CONTAMINATION OR CORROSION OF HOUSEHOLD PLUMBING OR SERVICE LINES	6	56
4. CONTAMINATION OF BROKEN, LEAKING MAINS	2	65
5. CONTAMINATION OF WATER MAINS DURING CONSTRUCTION OR REPAIR	2	1,423
6. CORROSION DUE TO CO_2 FROM SOFT DRINK MACHINE	1	74
	43	8,702
STORAGE FACILITIES		
1. CONTAMINATION OF DISTRIBUTION STORAGE	6	5,634
2. CONTAMINATION OF PRIVATE STORAGE TANK	3	331
3. CONTAMINATION OF CISTERN	1	5
	10	5,970

TABLE 4

WATERBORNE OUTBREAKS CAUSED BY MISCELLANEOUS DEFICIENCIES

1971-80

CAUSE OF OUTBREAK	OUTBREAKS	ILLNESSES
1. USE OF WATER NOT INTENDED FOR DRINKING	4	46
2. CONTAMINATED ICE	3	41
3. CONTAMINATED BOTTLED WATER	2	5
4. DELIBERATE CONTAMINATION	2	2,008
5. CONTAMINATED DRINKING FOUNTAIN	1	6
6. INSUFFICIENT DATA	6	1,379
	18	3,485

TABLE 5

CHEMICALS RESPONSIBLE FOR MULTIPLE OUTBREAKS OF WATERBORNE DISEASE

1971-80

CHEMICAL	OUTBREAKS	ILLNESSES
FLUORIDE	7	633
COPPER	6	103
CHLORDANE	4	2,043
PETROLEUM PRODUCTS	5	111
ARSENIC	2	19
NITRATE	2	2
HERBICIDES	2	5

TABLE 6

CAUSES OF CHEMICAL POISONINGS

1971-80

CAUSE OF OUTBREAK	OUTBREAKS
CONTAMINATION OF GROUNDWATER	10
CROSS-CONNECTION, BACKSIPHONAGE	9
DEFICIENCIES IN FLUORIDATION PRACTICES	7
LEACHING OF METALS FROM PLUMBING	5
DEFICIENCIES IN CHEMICAL FEED	2
DELIBERATE CONTAMINATION	2
CONTAMINATION OF PIPE WITH CUTTING OIL	1
CONTAMINATION OF STORAGE CONTAINER	1
INSUFFICIENT DATA	1

TABLE 7

WATER SYSTEM DEFICIENCIES RESPONSIBLE FOR WATERBORNE GIARDIASIS OUTBREAKS

1971-80

CAUSE	NUMBER OF OUTBREAKS			
	COMMUNITY WATER SYSTEM	NONCOMMUNITY WATER SYSTEM	INDIVIDUAL WATER SYSTEM	ALL SYSTEMS
1. INADEQUATE/INTERRUPTED DISINFECTION OF SURFACE WATER (WHEN ONLY TREATMENT)	12	5	-	17
2. UNTREATED SURFACE WATER	1	5	4	10
3. INEFFECTIVE FILTRATION	5	-	-	5
4. CROSS-CONNECTION	2	1	-	3
5. UNTREATED GROUND WATER	1	1	-	2
6. INTERRUPTED DISINFECTION OF SPRING	1	-	-	1
7. OTHER	-	-	1	1
TOTAL	22	12	5	39

TABLE 8

ETIOLOGY OF WATERBORNE OUTBREAKS IN COMMUNITY WATER SYSTEMS

1971-80

DISEASE	OUTBREAKS	ILLNESSES
GASTROENTERITIS, UNIDENTIFIED ETIOLOGY	55	28,928
GIARDIASIS	22	17,090
CHEMICAL POISONING	22	2,886
SHIGELLOSIS	10	3,788
SALMONELLOSIS	5	1,075
HEPATITIS A	5	130
CAMPYLOBACTER DIARRHEA	2	3,800
VIRAL GASTROENTERITIS	2	1,690
	123	59,387

TABLE 9

ETIOLOGY OF WATERBORNE OUTBREAKS IN NONCOMMUNITY WATER SYSTEMS

1971-80

DISEASE	OUTBREAKS	ILLNESSES
GASTROENTERITIS, UNIDENTIFIED ETIOLOGY	110	10,783
GIARDIASIS	12	2,390
SHIGELLOSIS	12	1,401
VIRAL GASTROENTERITIS	8	1,457
HEPATITIS A	7	305
CHEMICAL POISONING	7	645
SALMONELLOSIS	2	72
TYPHOID	1	210
TOXIGENIC *E. COLI* DIARRHEA	1	1,000
	160	18,263

TABLE 10

ETIOLOGY OF WATERBORNE OUTBREAKS IN INDIVIDUAL WATER SYSTEMS

1971-80

DISEASE	OUTBREAKS	ILLNESSES
GASTROENTERITIS, UNIDENTIFIED ETIOLOGY	12	134
CHEMICAL POISONING	9	63
GIARDIASIS	5	72
HEPATITIS A	4	28
TYPHOID	*	12
SHIGELLOSIS	2	6
SALMONELLOSIS	1	3
CAMPYLOBACTER DIARRHEA	1	21
	37	339

TABLE 11

CAUSES OF WATERBORNE DISEASE OUTBREAKS OF HEPATITIS A IN THE UNITED STATES

1946-80

CAUSE OF OUTBREAKS	NUMBER OF OUTBREAKS	
	COMMUNITY SYSTEMS	NONCOMMUNITY/INDIVIDUAL SYSTEMS
CONTAMINATED, UNTREATED SURFACE WATER	1	11
CONTAMINATED, UNTREATED GROUNDWATER	4	26
INADEQUATE OR INTERRUPTED DISINFECTION	3	6
CONTAMINATION THROUGH DISTRIBUTION SYSTEM	11	2
INSUFFICIENT DATA FOR CLASSIFICATION	3	2
TOTAL	22	47

TABLE 12

ETIOLOGY OF WATERBORNE OUTBREAKS OCCURRING
IN UNTREATED OR DISINFECTED ONLY WATER SYSTEMS

1971-1980

DISEASE	OUTBREAKS	CASES
SURFACE WATER SOURCES		
1. UNTREATED:		
GASTROENTERITIS	11	555
GIARDIASIS	10	312
OTHER	4	66
2. INADEQUATE DISINFECTION:		
GIARDIASIS	15	9,959
GASTROENTERITIS	8	4,661
OTHER	2	3,190
3. INTERRUPTION OF DISINFECTION:		
GASTROENTERITIS	11	1,920
GIARDIASIS	2	52
OTHER	2	84
WELL WATER SOURCES		
1. UNTREATED:		
GASTROENTERITIS	57	5,515
CHEMICAL POISONING	10	140
SHIGELLOSIS	10	995
HEPATITIS A	6	136
VIRAL GASTROENTERITIS	3	338
TYPHOID	3	12
OTHER	3	80
2. INADEQUATE DISINFECTION:		
GASTROENTERITIS	16	10,136
VIRAL GASTROENTERITIS	1	120
HEPATITIS A	1	50
SHIGELLOSIS	1	2,150
3. INTERRUPTION OF DISINFECTION:		
GASTROENTERITIS	25	5,559
SHIGELLOSIS	5	1,563
SALMONELLOSIS	3	291
VIRAL GASTROENTERITIS	2	405
HEPATITIS A	2	98
TYPHOID	1	210

TABLE 13

ETIOLOGY OF WATERBORNE OUTBREAKS CAUSED BY
CROSS-CONNECTIONS AND BACKSIPHONAGE

1971-80

DISEASE	OUTBREAKS	CASES
GASTROENTERITIS	13	1,208
CHEMICAL POISONING	9	608
GIARDIASIS	3	2,209
VIRAL GASTROENTERITIS	2	1,967
HEPATITIS A	2	56
SHIGELLOSIS	2	286
SALMONELLOSIS	1	750
	32	7,084

FIGURE 1

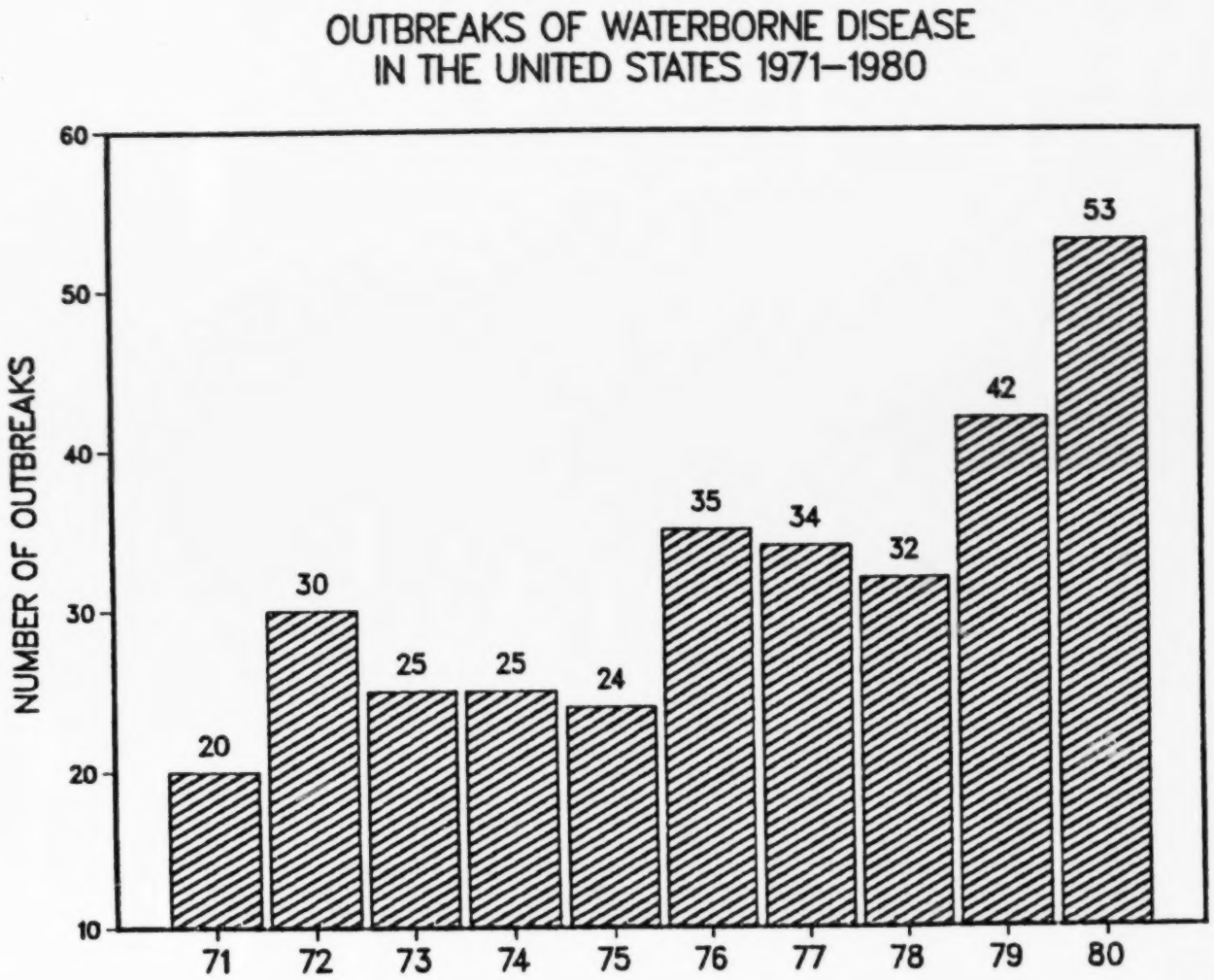
OUTBREAKS OF WATERBORNE DISEASE
IN THE UNITED STATES 1971–1980
NUMBER OF OUTBREAKS
60
50
40
30
20
10
20
30
25
25
24
35
34
32
42
53
71
72
73
74
75
76
77
78
79
80

FIGURE 2

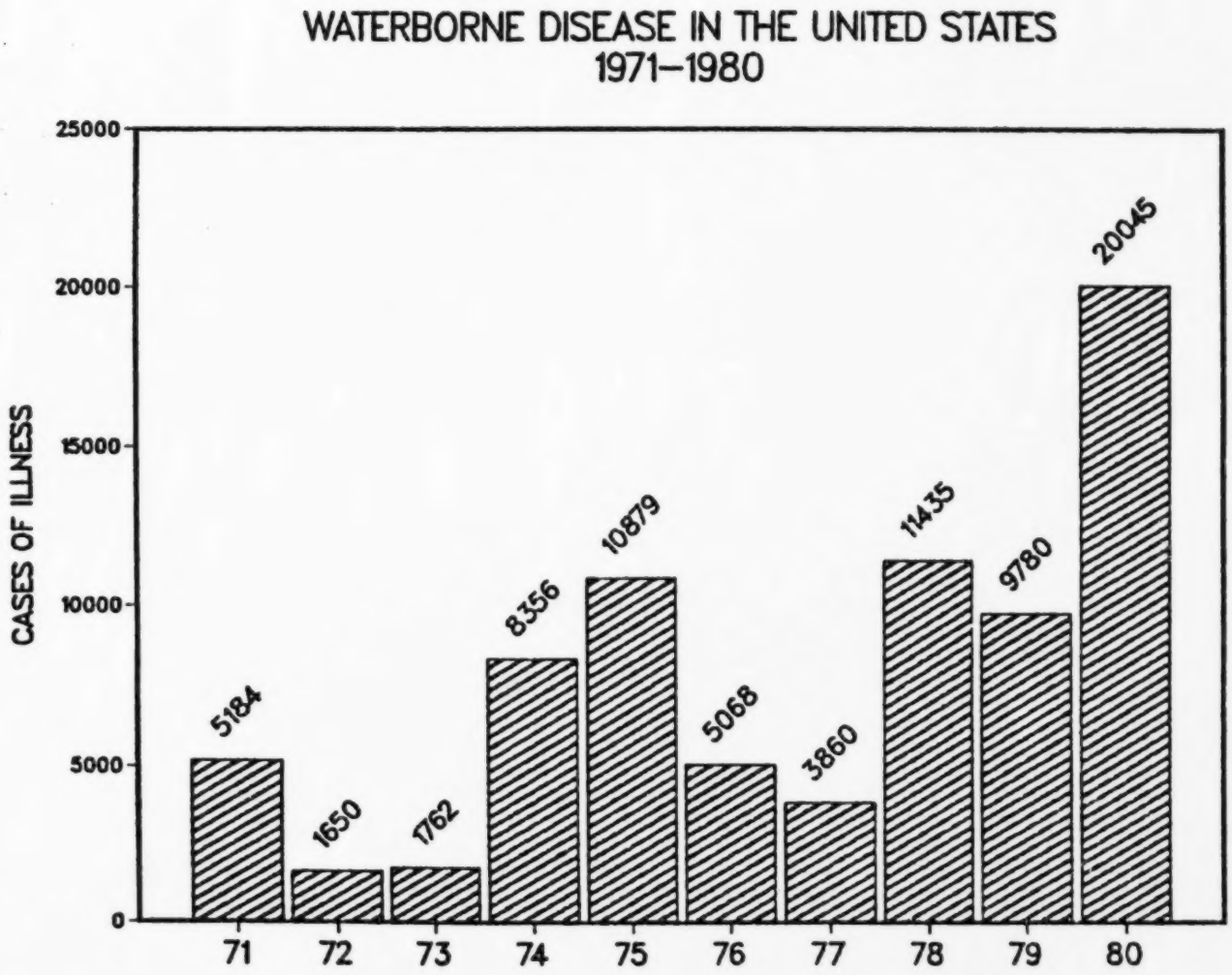
WATERBORNE DISEASE IN THE UNITED STATES
1971–1980
CASES OF ILLNESS
25000
20000
15000
10000
5000
0
5184
1650
1762
8356
10879
5068
3860
11435
9780
20045
71
72
73
74
75
76
77
78
79
80

FIGURE 3

WATERBORNE OUTBREAKS BY TYPE OF SYSTEM 1971–1980

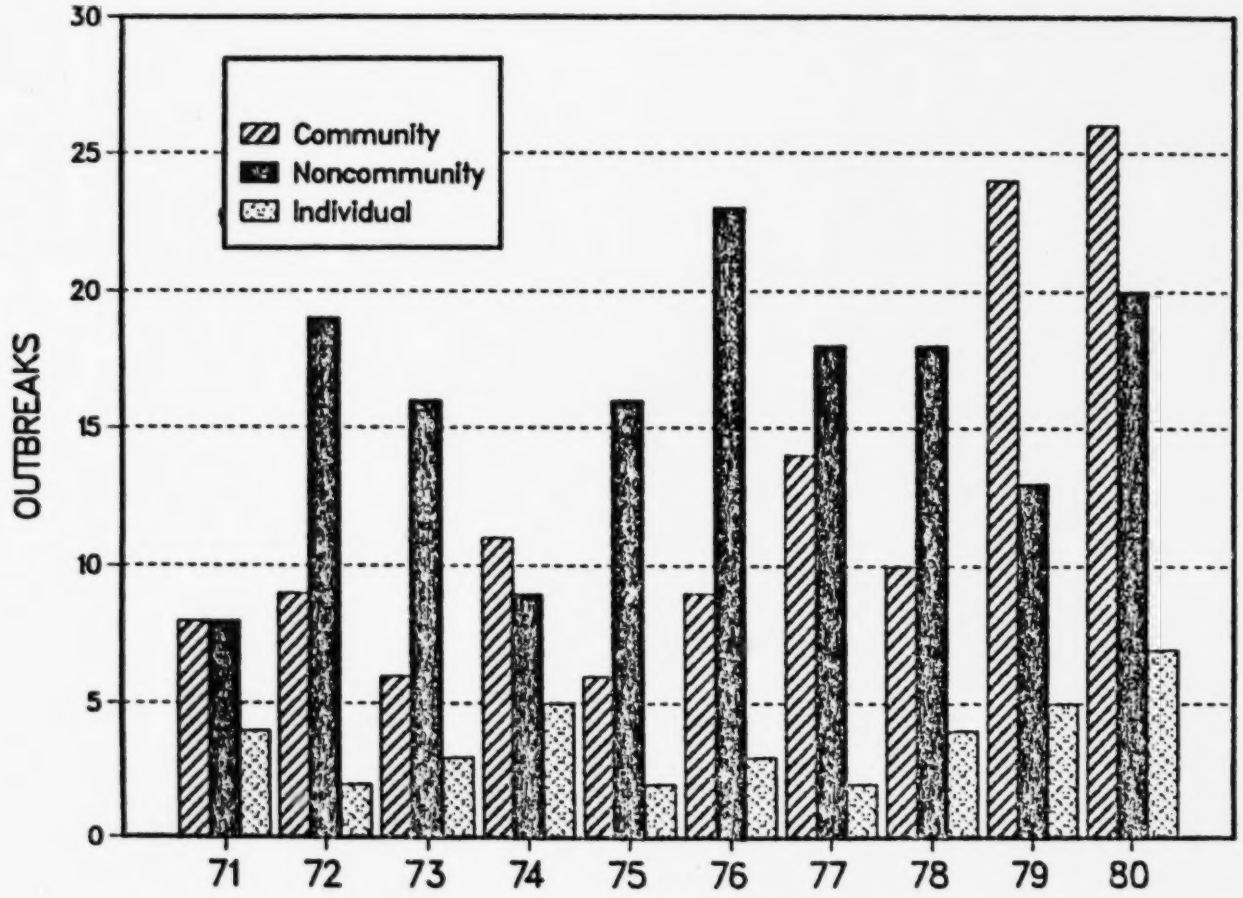

FIGURE 4

WATERBORNE OUTBREAKS BY TYPE OF SYSTEM 1971-1980

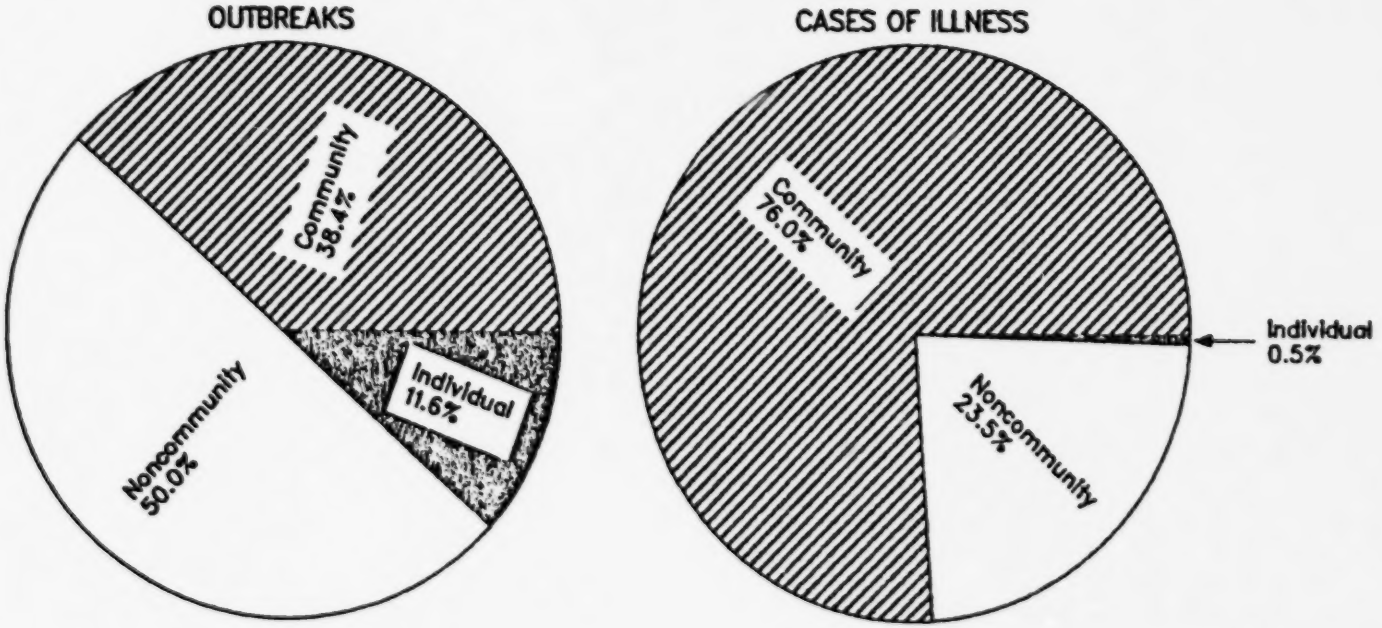

FIGURE 5

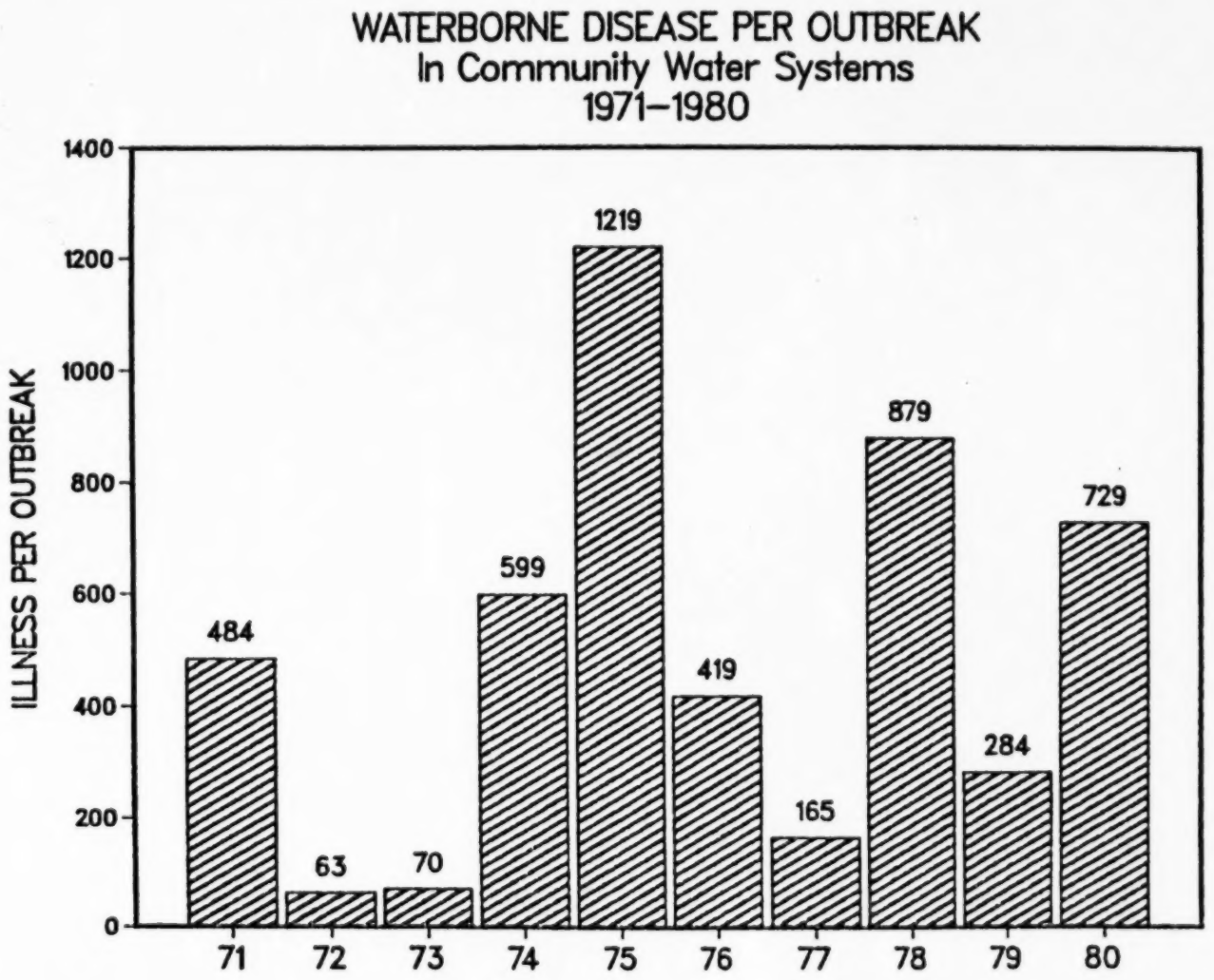
WATERBORNE DISEASE PER OUTBREAK
In Community Water Systems
1971–1980
ILLNESS PER OUTBREAK
1400
1200
1000
800
600
400
200
0
484
63
70
599
1219
419
165
879
284
729
71
72
73
74
75
76
77
78
79
80

FIGURE 6

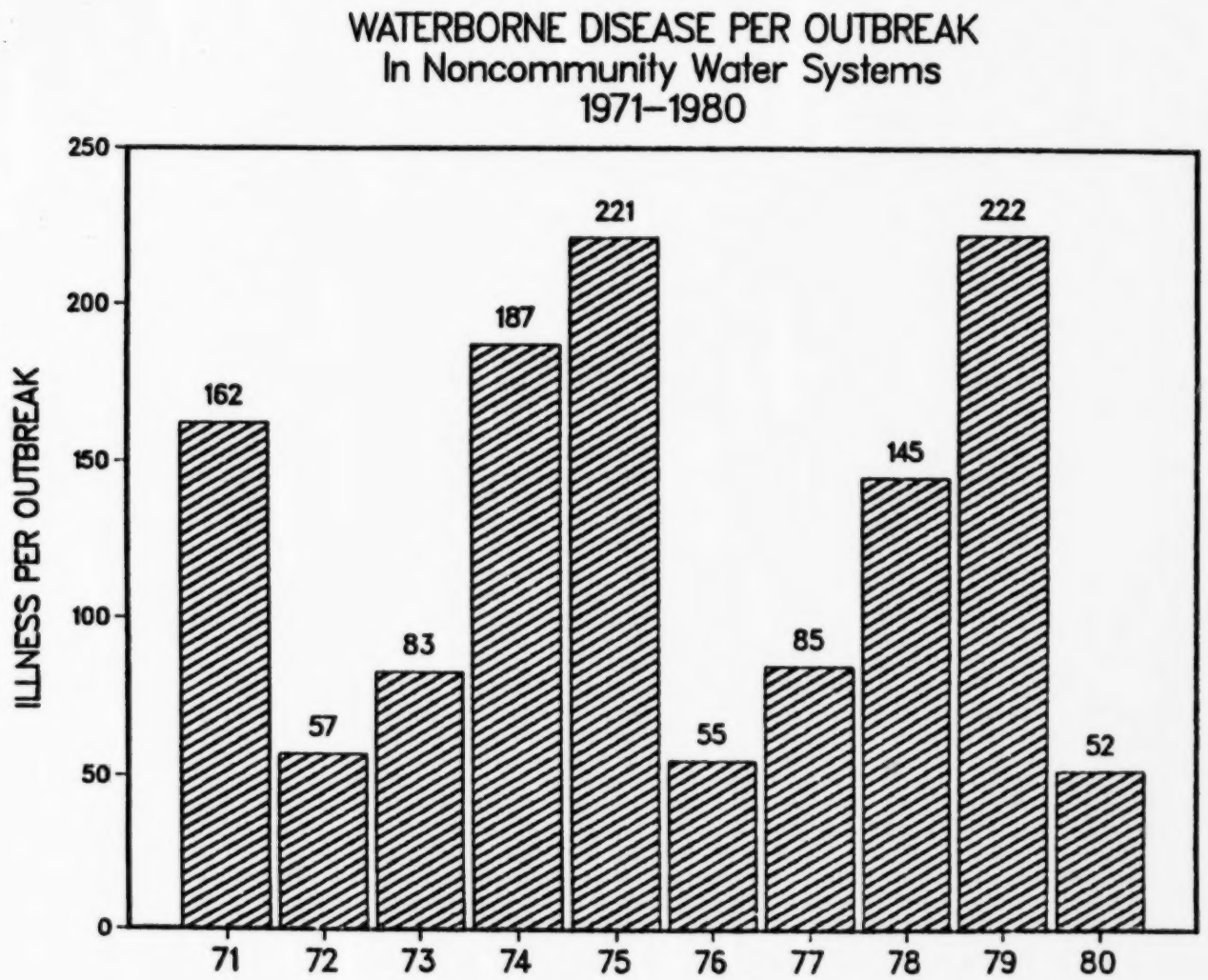
WATERBORNE DISEASE PER OUTBREAK
In Noncommunity Water Systems
1971–1980
ILLNESS PER OUTBREAK
250
200
150
100
50
0
162
57
83
187
221
55
85
145
222
52
71
72
73
74
75
76
77
78
79
80

FIGURE 7

NONCOMMUNITY WATER SYSTEMS

SEASONAL DISTRIBUTION OF WATERBORNE OUTBREAKS 1971–1980

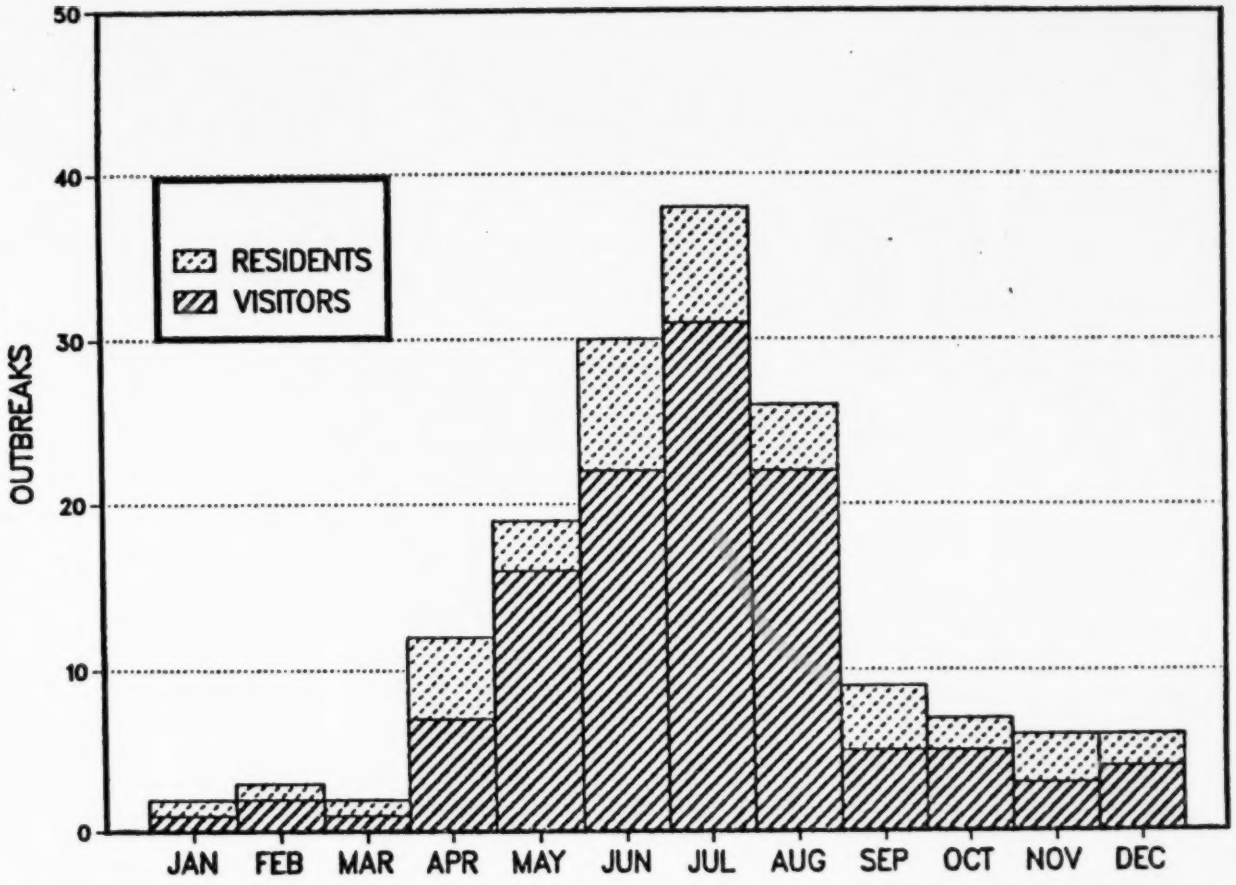

FIGURE 8

INDIVIDUAL WATER SYSTEMS

SEASONAL DISTRIBUTION OF WATERBORNE OUTBREAKS 1971–1980

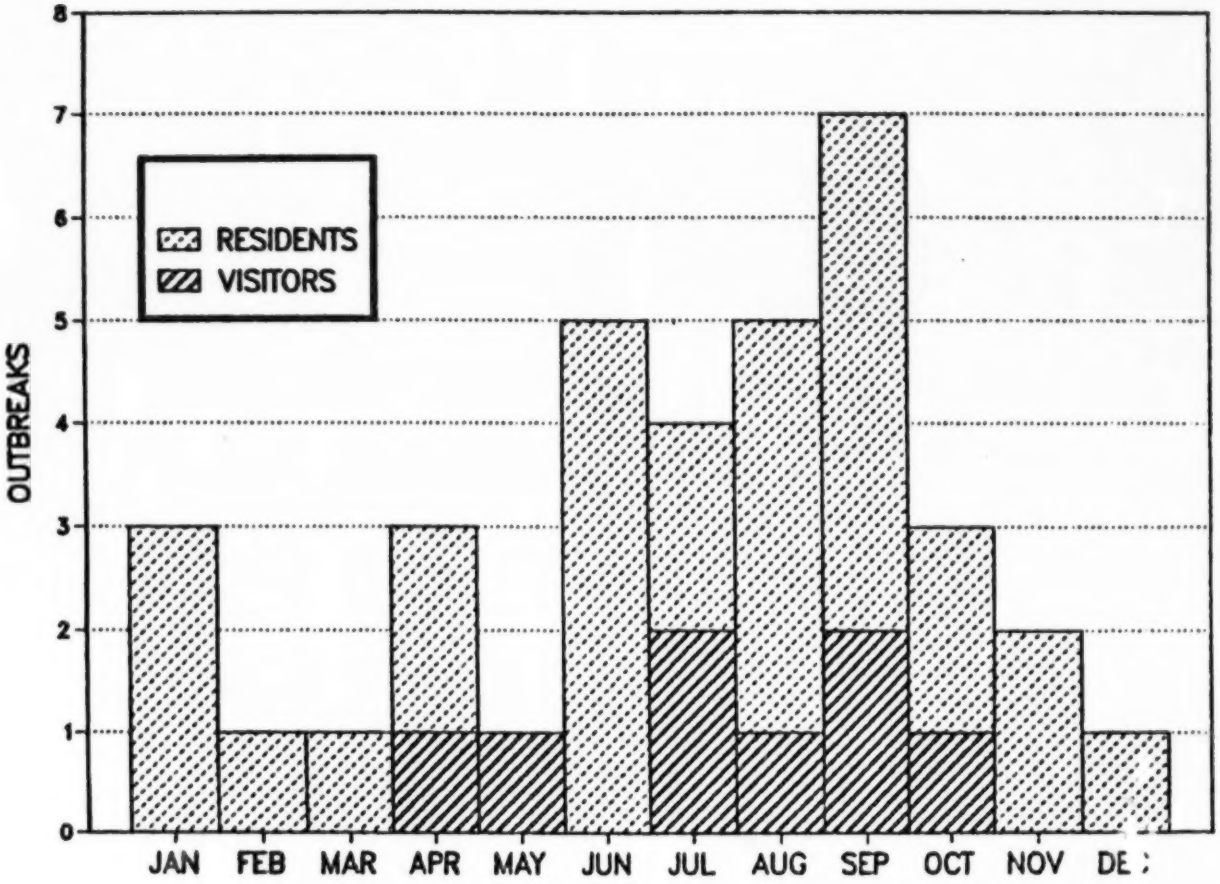

FIGURE 9

COMMUNITY WATER SYSTEMS

SEASONAL DISTRIBUTION OF WATERBORNE OUTBREAKS 1971–1980

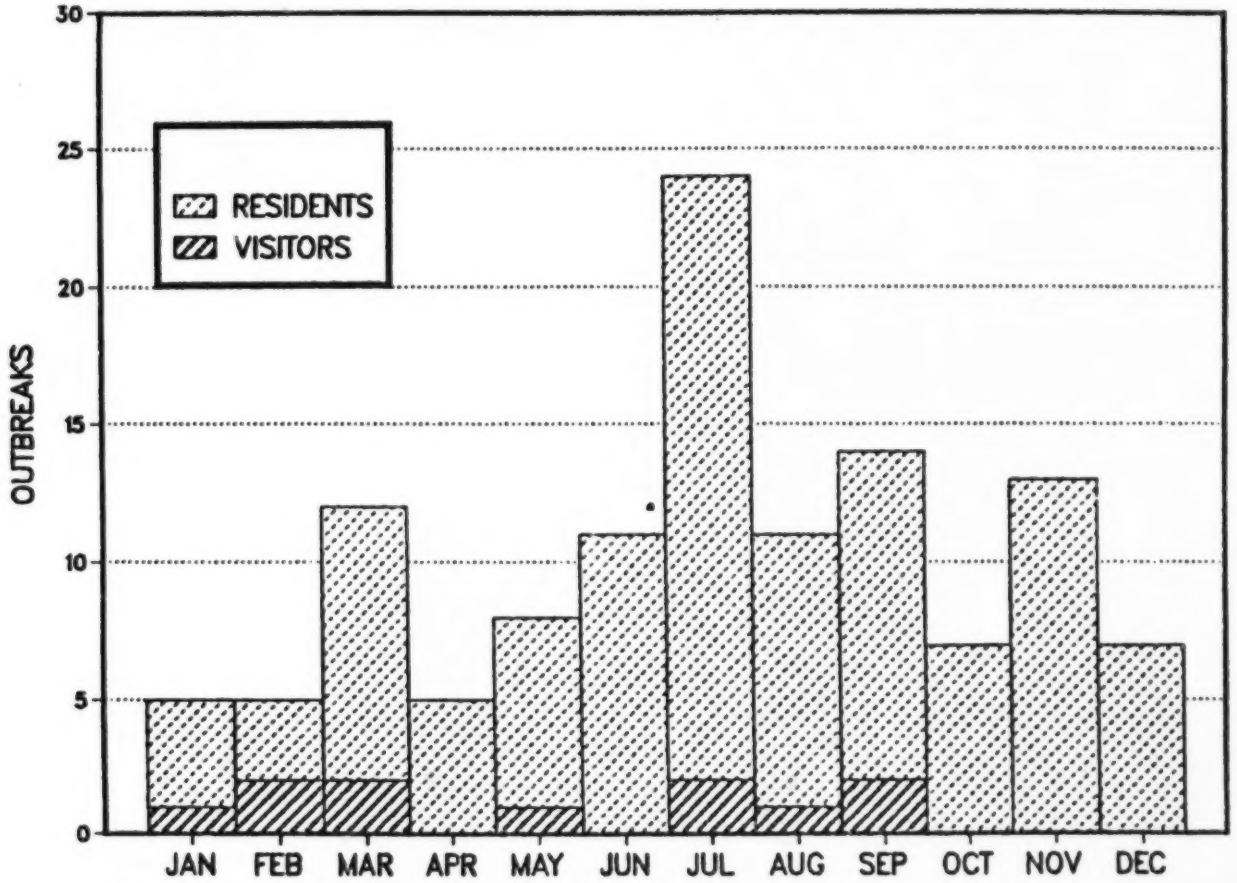

FIGURE 10

CAUSE OF WATERBORNE OUTBREAKS
In The United States
1971–1980

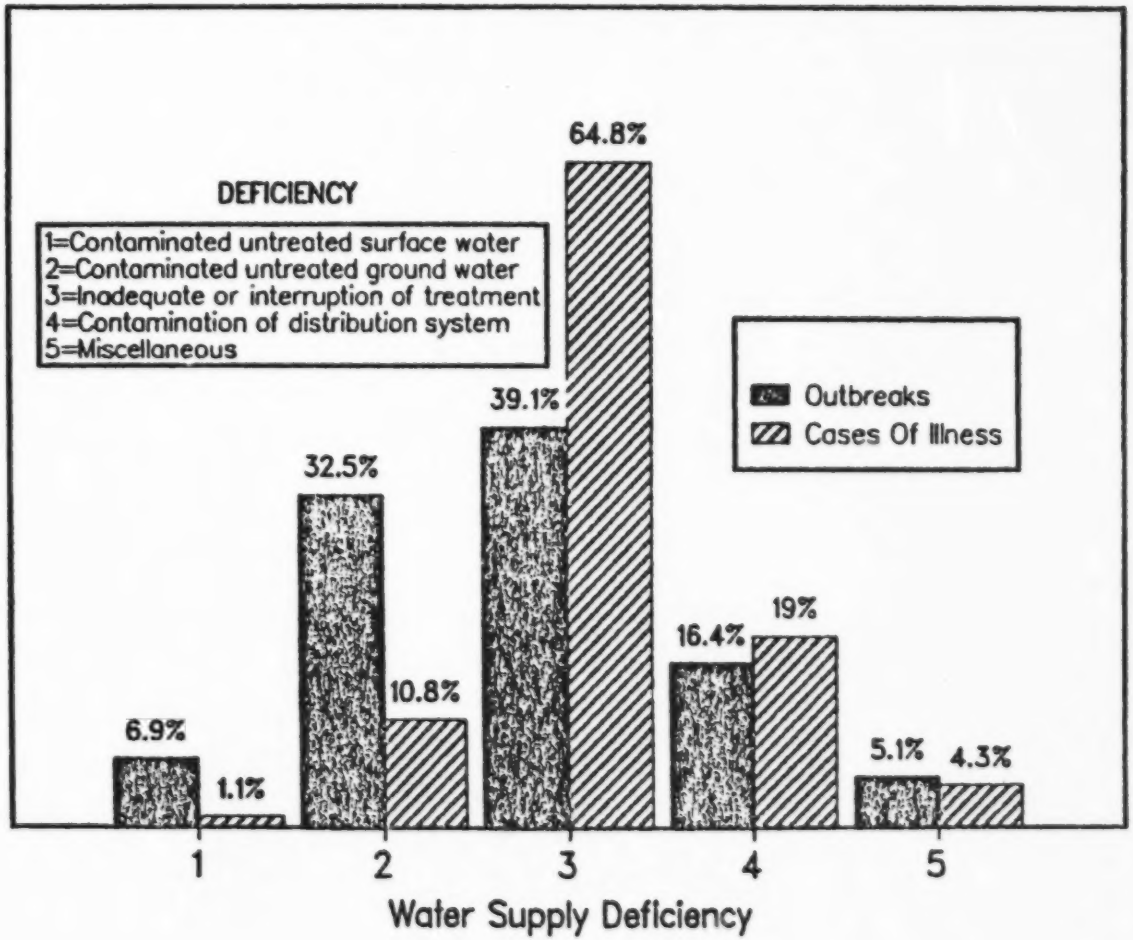

FIGURE 11

SURFACE WATER SYSTEMS

SEASONAL DISTRIBUTION OF WATERBORNE OUTBREAKS 1971–1980

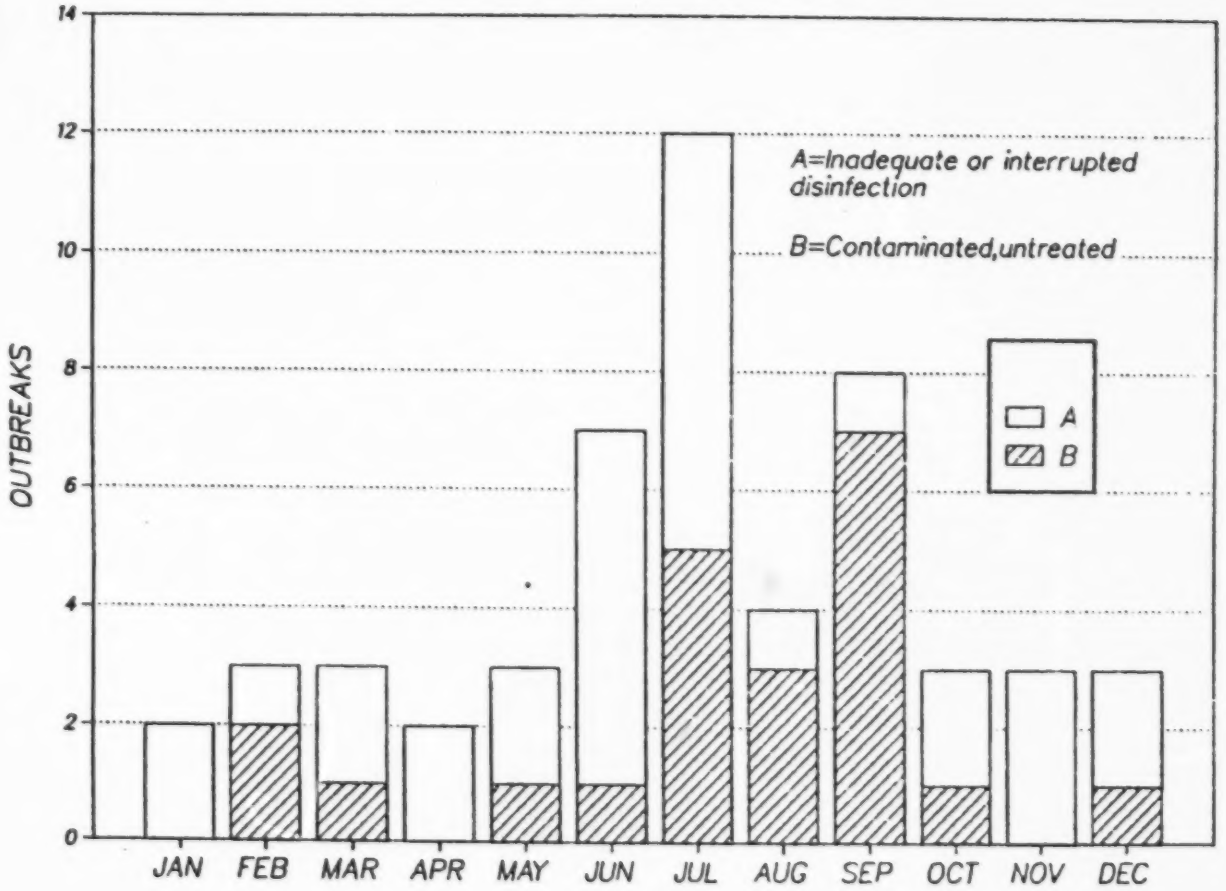

FIGURE 12

GROUND WATER SYSTEMS

SEASONAL DISTRIBUTION OF WATERBORNE OUTBREAKS 1971–1980

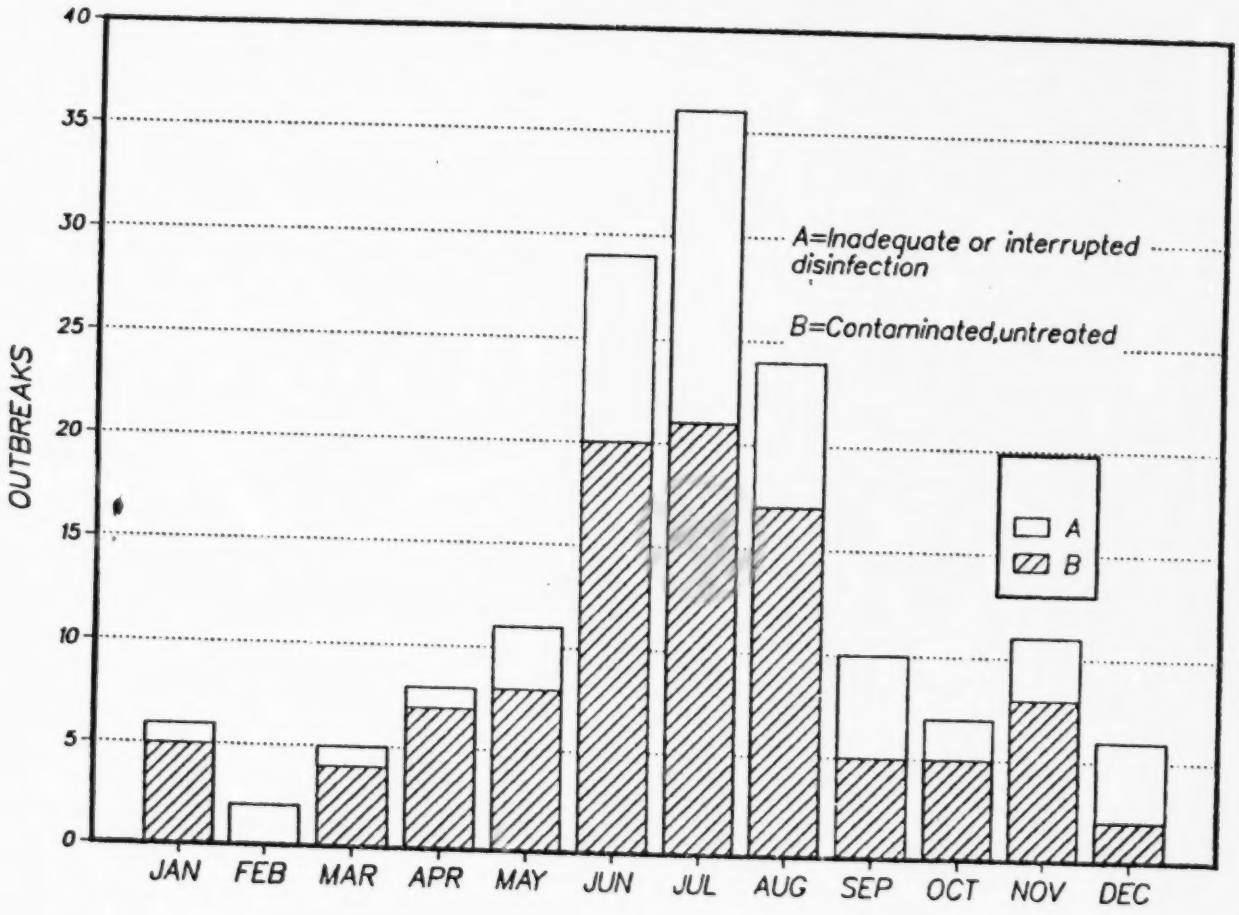

FIGURE 13

COMMUNITY WATER SYSTEMS

CAUSE OF WATERBORNE OUTBREAKS BY SYSTEM DEFICIENCY 1971–1980

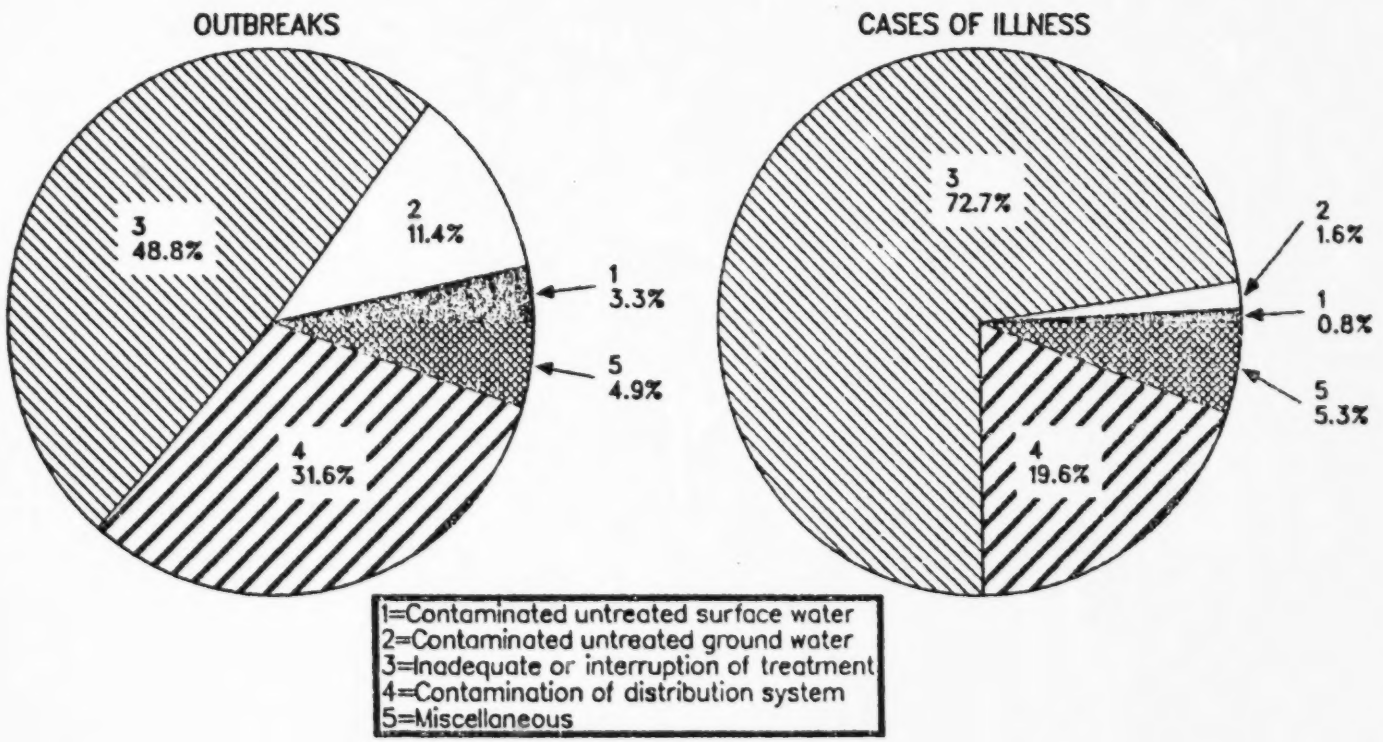

FIGURE 14

NONCOMMUNITY WATER SYSTEMS

CAUSE OF WATERBORNE OUTBREAKS BY SYSTEM DEFICIENCY 1971–1980

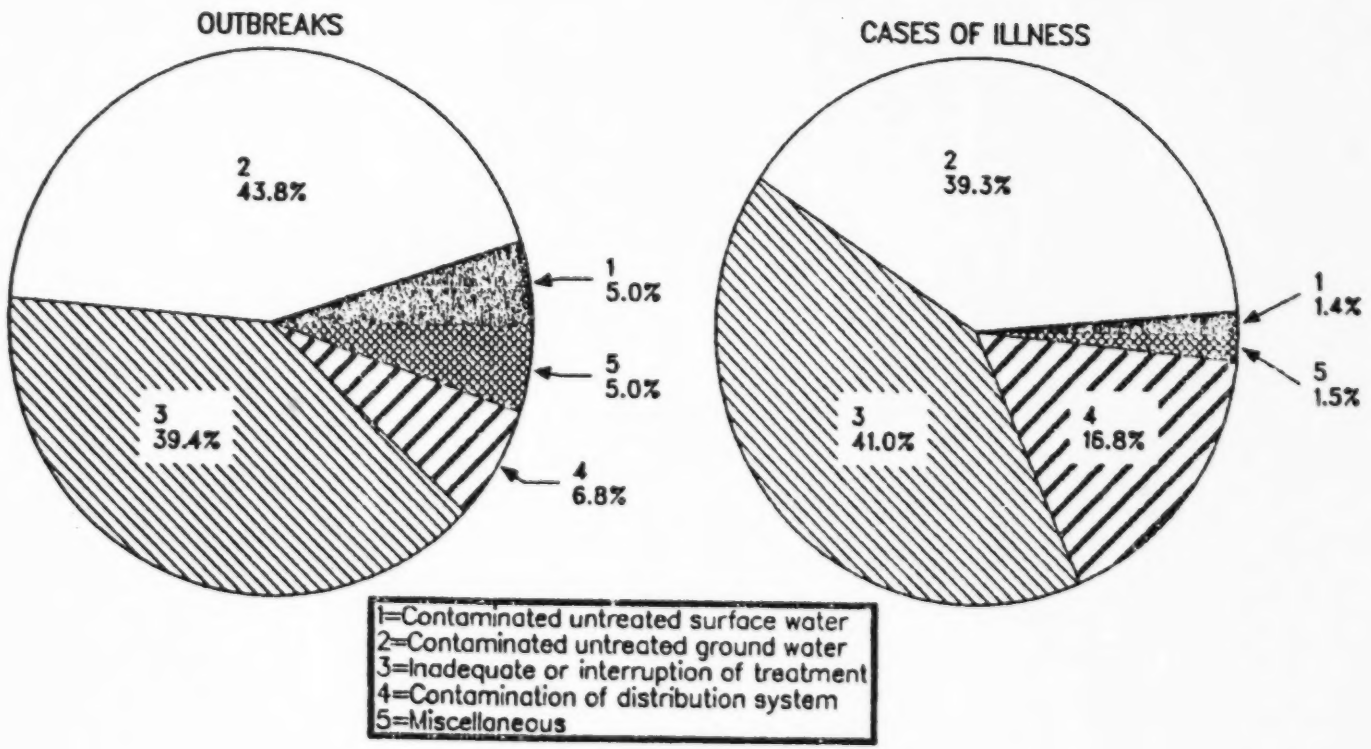

FIGURE 15

INDIVIDUAL WATER SYSTEMS

CAUSE OF WATERBORNE OUTBREAKS BY SYSTEM DEFICIENCY 1971–1980

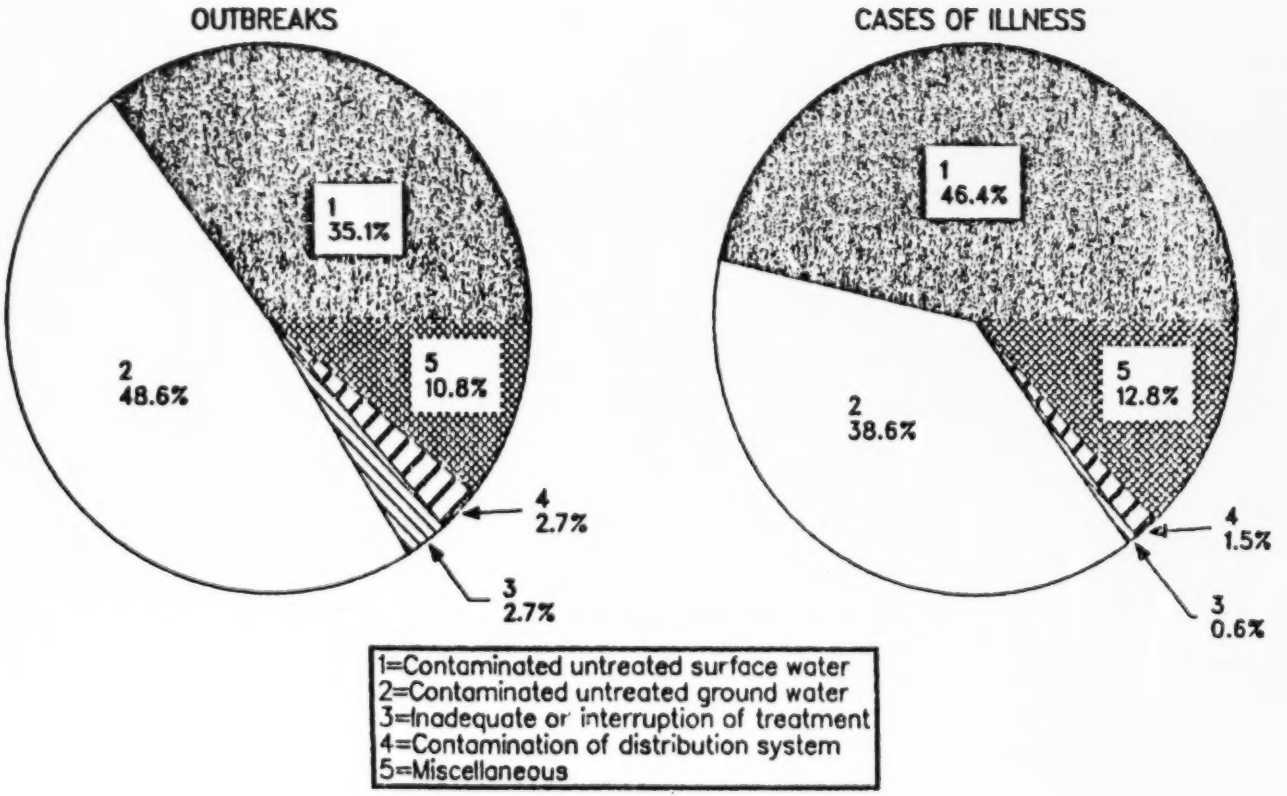

FIGURE 16

ETIOLOGY OF WATERBORNE OUTBREAKS
1971–1980

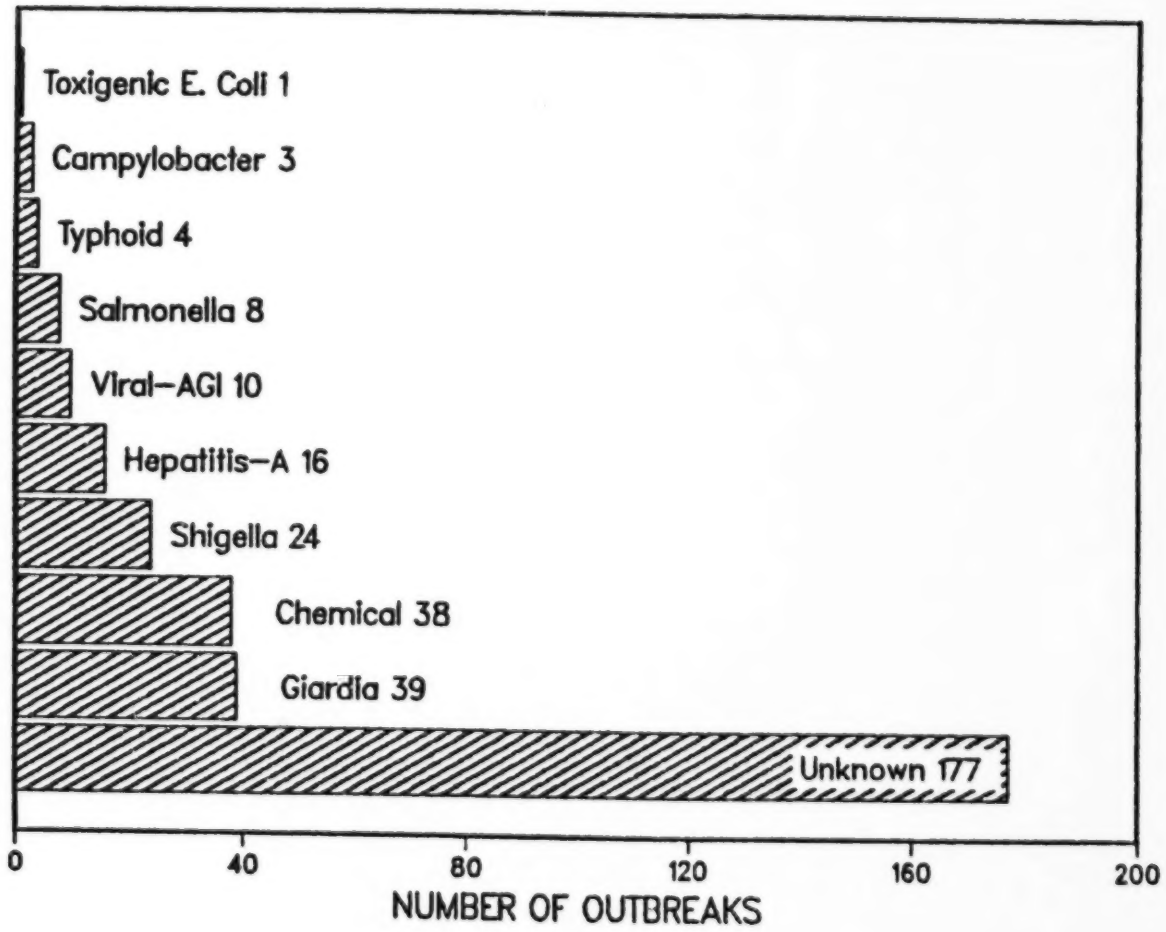

FIGURE 17

ETIOLOGY OF WATERBORNE OUTBREAKS
1981

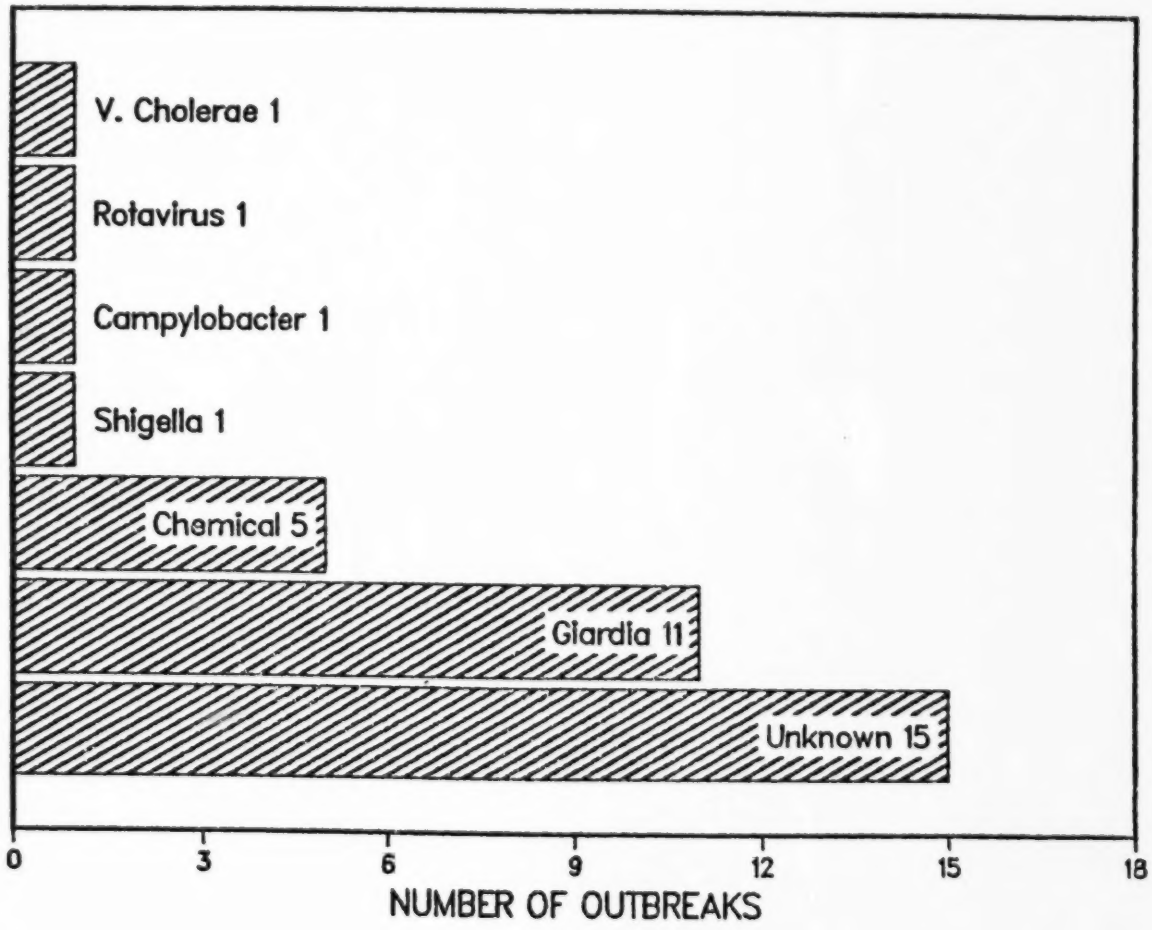

FIGURE 18

CASES OF WATERBORNE DISEASE OF DEFINED ETIOLOGY
OCCURRING IN WATERBORNE OUTBREAKS
1981